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DIURNAL EFFECT OF PM10 AND NOX ON CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND ASTHMA IN ABUJA NIGERIA

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ABSTRACT

Introduction: Air pollution is emerging as a crucial risk factor for respiratory health problems like Chronic Obstructive Pulmonary Disease (COPD) and asthma in developing countries, including Nigeria where air pollutant concentrations are elevated. In these countries, urban and peri-urban areas like Abuja bear the bulk of the problem. Nevertheless, data on the health effects of air pollution and pollutants are limited. This study aimed to critically examine the health effects of particulate matter less than 10 μg/m3 (PM10), and nitrogen dioxide (NO2) in Abuja FTC, Nigeria.

Methodology: The diurnal effect of PM10, and NO2 concentrations was used to examine COPD and asthma patients due to exposure to these pollutants from November 2015 to December 2018. PM10 and NO2 air concentrations were monitored by the Nigerian Metrological Agency throughout the study. The 402 participants recruited were part of a major study which examined the effect of photochemical smog on COPD and asthma patients. For this study, participants completed the Medical Research Council (MRC) dyspnoea questionnaire; lung function tests was performed to determine the airway obstructive level in association with the pollutant at varying concentrations.

Results: The 24-hour mean of PM10 was 296.7μg/m3, and the NO2 1-hour mean was 253.1μg/m3, which are both higher than the WHO set thresholds. The diurnal variation of PM10 varied from an average of 149.5μg/m3 in the morning to 345.3μg/m3 during the afternoon (dry season) and 108.5μg/m3 to 250.4μg/m3 (wet season). The PM10 increase was significantly associated with decreased forced expiration volume (FEV)1 and forced vital capacity (FVC) in the participants (-786, P=.000); with a moderate significant association between NOx and

FVC (-.582, P= .018). A significant association was also observed between PM10 with Dyspnoea (-.786, P=.000). When we stratified for gender, it was observed that women had a higher significance P=.001 and for every 10 μg/m3 increase in NO2 and PM10 concentration above the WHO recommended 24hr thresholds, the relative risk for developing respiratory symptoms was 1.09 (95% CI: 1.07 to 1.05) and 1.06 (95% CI: 1.01 to 1.10), respectively.

Conclusion/Recommendation: There is high level of pollutant concentration with strong association with COPD and asthma symptoms in FCT Abuja. Immediate policies and actions are needed to reduce pollutants from various sources including from transport and energy manufacturing facilities.

KEYWORDS

COPD, asthma, Air pollution, PM10, NO2, FCT Abuja, Nigeria

INTRODUCTION

Air pollution affect people from developing countries disproportionately and has emerged as a risk factor for respiratory health conditions such as chronic obstructive pulmonary disease (COPD), asthma, and many other health problems in developing countries, including Nigeria where air pollutant concentrations are elevated (Forouzanfar, et al., 2015; World Health Organisation, 2022; Ihedike, Mooney, & Ling, 2023). These respiratory conditions caused by air pollution add to the burden of non-communicable diseases in countries with limited resources. Nevertheless, the data on the health effects of air pollution are limited.

Several studies have shown the effects air pollution exposure has on respiratory health (Orellano et al., 2017; Huang et al., 2022). However, results have remained inconsistent. Moreover, the effects investigated by those studies have been largely instantaneous and diurnal effects of air pollution have not been adequately considered.

It is estimated that air pollution causes 7 million deaths every year and is such the biggest contributor to environment health risk (World Health Organisation, 2018&2022). The WHO has set out guidelines and standards (thresholds) on air quality levels, based on daily mean air pollutant concentrations (World Health Organisation, 2021).

Although investigating instantaneous effects can inform us about the relationship between intensity of air pollutant exposure and health outcomes at the point of observation, it does not address the potential diurnal effect of exposure on outcomes (Gasparrini and Leone, 2014). In fact, changes in exposure to air pollution may have different health impacts, which is not adequately addressed in literature. It is important to study diurnal pollutant effects to understand how patterns of pollutant exposure might be impacted by pollution episodes during the day. Hence, there is a need to study the change of air pollution effect during the day on respiratory problem such as COPD and asthma (Gasparrini, 2014, Ihedike, Ling and Mooney 2022).

This study aimed to critically examine the health effects of particulate matter less than 10 μg/m3 (PM10), and nitrogen dioxide (NO2) in Abuja FCT Nigeria. This study helped to investigate the diurnal effect of PM10 and NO2 on COPD and asthma.

METHODOLOGY

Study design and setting

This was a prospective population-based cohort study using COPD and asthma patients diagnosed and registered in two government owned hospital in Abuja FCT, Nigeria. Abuja is the federal capital territory, situated at the centre of Nigeria. Abuja's population is about 3,277,740 and is inhabited by a range of people from civil servants, bussinesses, to farmers (World Population Review, 2020). According to the World Population Review (2020), Abuja is a fast-developing city with high road traffic and high diesel generator use due to frequent power outages.

The need to evaluate the diurnal effect of NOx and PM10 on asthma and COPD patients in Abuja FCT is vital because of the growing population, use of electric generators, bush burning, mining, and emission of NOX and hydrocarbons, among other factors. Also, exhausts from vehicles contribute notably to the concentration of the pollutants in the air. Consequently, this causes a high rate of NOx and PM10 concentrations (Caiazzo et al., 2013; Pratama et al., 2019, Liu et al., 2021).

Study population.

Adult respiratory health patients (male and female aged 18 and above) living in Abuja FCT and registered in either of the two hospitals. A total of 402 participants were involved in the research. Participants were contacted through the respiratory clinic/department of the respective hospitals. The procedures of data collection were previously described in detail in a previous related publication (Ihedike and Ling, 2022). In brief, we obtained data on demographic characteristics, and medical history, and measured lung function tests using Spirometry.

Data collection and assessment tools

Air quality data and meteorological data were monitored by the Nigerian meteorological agency (NIMET) within the period of study. The study's respiratory health data were collected using the following assessment tools: respiratory symptom questionnaire, daily diaries, Medical Research Council (MRC) dyspnoea scale and lung function test using Spirobank Basic II.

Statistical analysis

The daily air pollutant concentrations (NO2 and PM10) were descriptively summarised. The correlation and relative risk were performed using version 28 of the Statistical Package for the Social Sciences (SPSS) (IBM, 2020). A p-value of <0.05 or less at a 95% confidence interval was taken as significant.

Data source

Anonymised hospitals and outpatient information were obtained from hospitals used for this study. Participant’s daily symptoms due to COPD and asthma were recorded. Air pollutants (NO2 and PM10) were collected by (Nigerian Meteorological agency Abuja FCT (NIMet) at their monitoring site. The site provided NO2 and PM10 measurements (Table1). The Sensors recorded hourly measurements which were quality checked, validated and ratified then daily mean concentrations were calculated for each air pollutant. Using SPSS, both parametric and non-parametric comparison analysis were done (Hopkins, Dettori, & Chapman, 2018; Frost,2020; Ranganathan, 2021).

Ethics approval

Ethical approval was obtained from university of Sunderland and the hospitals used for this study.

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RESULT

Descriptive summary

During the study 402 participants gave consent and participated in the study. Participants keep daily diary of their symptom and lung function measured. The study showed the same pattern as the respiratory symptoms with peaks during the dry season months. See Table 1

Table 1. Diurnal effects of NO2 and PM10 on respiratory symptoms

Symptoms	**RR (95% CI)**	**AR (95% CI)**	**AN (95% CI)**
NO_2 (1-hour mean= 253.1μg/m^3)	1.09 (1.07–1.11)	10.1% (7.9–12.2)	10,674 (9891 - 13,006)
PM_{10} (24-hour mean= 296.7μg/m^3)	1.03 (0.94–1.13)	0.05% (0.0–0.2)	61 (0–234)

Note: AN attributable number; AR, attributable risk; CI, confidence intervals; NO2, nitrogen dioxide; PM, particulate matter; RR, relative risk.

There was a significant excess risk of respiratory symptoms due to NO2 exposure (attributable risk = 11.2%, 95% CI: 9.0 to 13.1). The excess risk for PM10 exposure was also marginally significant (attributable risk = 0.6%; 95% CI: 0.1 to 1.1). The respective attributable number of respiratory symptoms due to NO2, and PM10 were 10,674 (95% CI: o 9891 to 13,006), and 61 (95% CI: 0 to 243). See Table 1 for further details.

Table 2. increase respiratory symptoms due to increasing air pollutants concentrations

	RR (95% CI)	**AR (95%CI)**	**AN (95%CI)**
NO_2 (24hour-hour mean= 112.4 μg/m^3)	1.98 (1.82–2.15)	49.9% (45.8–53.6)	4928 (4521 to 5285)
PM_{10} (149.5μg/m^3)	3.55 (1.85–6.84)	2.1% (1.0–3.0)	205 (98–296)

Note: AN, attributable number; AR, cumulative attributable risk; NO2, nitrogen dioxide; PM10, particulate matter 10; RR, relative risk.

The relative risks of increased respiratory symptoms due to the exposure to increasing pollutant concentrations higher than WHO '24-hr mean' for NO2, and PM10 at were 1.98 (95% CI: 1.82 to 2.15), 4.52 (95% CI: 3.37 to 6.07) and 3.55 (95% CI: 1.85 to 6.84), See Table 2.

Table 3 Correlation between NO2, PM10 FVC, FEV1, Dyspnoea and by gender FVC and FEV1

			FVC/ FEV_1	Dyspnoea	Female FVC/FEV_1	Male FVC/FEV_1
Spearman's rho	PM_{10}	Correlation Coefficient	-0.786**	.768**	.756**	589*
		sig. (2-tailed)	.000	.000	.001	.019
	NO_2,	Correlation Coefficient	-0.582	.705**	.703	.698*
		sig. (2-tailed)	.018	.002	.001	.002

The result of the analysis above showed a significant strong negative correlation with FVC/ FEV1 and PM10 and positive association with dyspnoea. Thus, increase in correlation strength was observed from the correlation analysis.

Health service use cost

The estimated cumulative costs attributable due to NO2 exposure were £1,675,026 (95% CI: 1,513, 498.6 to 1,606,607.63). At their respective 'increasing concentrations cumulative attributable cost due to exposure to PM10 were £56,082.57 (95% CI: 48,803.46 to 89,961.04), respectively.

DISCUSSION

In this study, we investigated the diurnal effect of PM10 and NOx on COPD and asthma patients in Abuja FCT, Nigeria. We observed that the daily concentrations of NO2 and PM10 had an immediate impact on the symptoms of COPD and asthma patients which is evidenced in the correlation analysis, relative risk, excess risk and attributable number of illnesses estimates per the increasing pollutant concentrations (Table 1,2, &3). The increase of NO2 concentration above WHO 24-hr mean threshold (25 μg/m3) was linked to a 10% excess risk of symptoms.

The daily effect of the two pollutants (NO2, and PM10) was also significantly high. The increase in NO2 and PM10 above the WHO recommended level was associated with cumulative attributable risks 50% of increased symptoms due to pollutants concentrations. This has been confirmed by other studies on the effect of the pollutant concentrations on lung function and symptoms of COPD and asthma patients (Ihedike & Ling, 2022; Huang et al., 2022, Ihedike, Ling &Mooney, 2023; Mebrahtu et al., 2023). The resulting morbidity (and mortality) from COPD and asthma contributes significantly to the existing and growing burden of non-communicable illnesses in developing countries like Nigeria.

However, immediate effect of exposure to NO2, and PM10 on respiratory health has been inconsistent in previous studies due to the variation in concentrations assessed (Doiron et al., 2019; Park et al., 2021 Salimi et al., 2022). In a meta-analysis of five studies (Park et al., 2021), a 10 μg/m3 increase in the exposure of NO2

(Hazard Ratio (HR) = 1.07; 95% CI: 1.00 to 1.16) and PM2.5 (HR = 1.18; 95% CI: 1.13 to 1.23) was associated with increased incidence of COPD, whilst every increase in PM10 (HR = 0.95; 95% CI: 0.83 to 1.06) appeared to be associated with increase COPD symptoms.

On the contrary in a cohort study by Schikowski et al. (2014), an increase of 10 μg/m3, 5 μg/m3 and 10 μg/m3 in NO2 (Odds Ratio (OR) = 1.05; 95% CI: 0.89 to 1.23), PM2.5 (OR = 1.06; 95% CI: 0.73 to 1.53) and PM10 (OR = 1.10; 95% CI: 0.70 to 1.73), respectively, was not related with significant increase in COPD symptoms occurrence. More studies have reported increased prevalence of COPD with increasing exposure to NO2, and PM10 (Liu et al., 2017; Doiron et al., 2019, Ihedike, Ling &Mooney, 2023). A time series study also observed increased respiratory illnesses and use of health facilities due to high level of pollution (Mebrahtu et al., 2023). In addition, Tornevi, Olstrup, & Forsberg, (2022) revealed an association between increased respiratory visits with increasing concentrations of PM10. Another study in the United Kingdom reported a stronger relationship between PM10 and reduced lung function (Doiron, etal., 2019) whilst no significant effect of exposure to NO2 on respiratory symptoms or admission (Salimi et al., 2022).In a meta-analysis of 27 studies (Huang et al., 2022), an increase of 10 μg/m3 in the NO2, and PM10, were linked to an increased risk of asthma exacerbations by 1% (RR = 1.01; 95% CI: 1.01 to 1.01). In this study, we observed significant increases in respiratory symptoms, reduced lung function which were both significantly associated with increasing concentration of air pollutants.

We used 402 participants that kept daily diaries of their experience during dry and wet seasons and measured their lung function while the pollutants were monitored at the time this study was conducted. This is a strength to this study, the first study on diurnal effect of NO2, and PM10 on COPD and asthma conducted in Abuja FCT, Nigeria. However, this study had some limitations. Only one site was used to monitor the air pollutants. Patients report their daily symptoms, and we presumed that the participants were those suffering from COPD and asthma during the study, although this is true, our study did not include a representative sample of all COPD and asthma patients during the time of the study. Inadvertently, only two government owned hospitals were used.

CONCLUSION

The diurnal effect of PM10 and NOx on COPD and asthma patients were evident in this study. The increased concentration pollutants lead to increase in symptoms and reduced lung function. Taking this effect on the patients into account, hospital visits, admission, and emergency visits due to COPD and asthma are likely due to increasing concentration of the pollutants. This will have extensive financial impact on the patients and relatives. The outcome of this study is vital to government, policy makers and actions are needed to reduce the various sources of these pollutants from transport, diesel generator use, and energy manufacturing facilities.

Tracking of air quality around WHO recommended 24-hr mean estimates will be vital to recognise periods of peak demand. However, due to the huge environmental and health effect of air pollution the implementation of policies to reduce air pollution are necessary.

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